

Processes and Signatures of Sediment Supply, Redistribution, and Accumulation on an Accretionary Continental Margin

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LONG-TERM GOALS

The long-term goal of this project is to determine what sedimentary processes are important in the formation and development of the continental margin in an accretionary system. To this end, I am examining the rates and products of slope sedimentary processes that contribute to redistribution and accumulation of sedimentary material. Thus, this project is examining distinct slope sedimentary environments to determine rates of sediment accumulation on a variety of timescales and is examining the preserved record of these processes in the sediment column.

OBJECTIVES

The focus of this two-year project is to document the important sedimentary processes on the continental slope (i.e., sediment accumulation, erosion, and redistribution) and how these processes are recorded in the sedimentary strata of continental margins. The specific objectives of this project are:

- to use short-lived radiochemical tracers for the documentation of slope sediment delivery.
- to determine the rates of sedimentary processes on 1-yr, 100-yr and 1000-yr timescales.
- to determine the role of slope gullies in sediment dispersal.
- to delineate the Eel River dispersal system and calculate a sediment budget for the slope.
- to determine the importance of submarine canyons in the redistribution of fluvial material.

During the first year of the project, I focused on the first two goals, with an emphasis on shorter timescales (1-100 y). During the second year, that covered by this report, I have focused on the remaining longer timescales (100-1000 y) and on sediment dispersal pathways in an effort to come to closure on the sediment budget.

APPROACH

Samples to allow us to achieve these objectives were obtained through seabed sampling on a variety of length scales. Sediment cores (0.5-9 m in length) have been collected to investigate processes that dominate on 1-1000 year time-scales. Work has been focused on completing analyses of a unique suite of cores collected with the MBARI ROV *Ventana*, analyzing cores collected during the past year, and in collecting additional cores in unsampled regions that are critical to achieving the goals outlined above. In this second year, rates of processes are being examined using longer-lived radiotracers pertinent to the longer timescales being examined (^{210}Pb and ^{14}C). Examination of sedimentary properties in longer cores and over longer timescales will be used to provide a more thorough understanding of those processes that leave their signature in the geologic record.

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WORK COMPLETED

Two cruises have been completed this year (March and July), with the major core collection effort occurring in July 1998. The July cruise was multidisciplinary in nature and for my program focused on finalizing the shelf/slope sediment budget by sampling in the heads and at the bases of the Trinity and Eel Canyons. Long (1-3 m), large-diameter Lehigh cores were collected in most areas to facilitate high-resolution time and sedimentary stratigraphy. Of particular note are two cores collected at the base of the Trinity and Eel Canyons, where thick, interbedded muds and sands were cored that should yield an estimate of down-canyon flow volume and frequency. During this same cruise, we collected cores for H. Lee and J. Locat, who performed onboard geotechnical analyses, and for D. Orange who later analyzed gas content; time was provided for K. Ruttenberg to collect CTD data, and for H. Christian to repeatedly deploy a piezometer that measures *in-situ* pore pressures.

Because several cruises take place each fiscal year, core subsampling and sample analysis is an ongoing operation. The long piston cores collected during this project have been subsampled in November 1997 and June 1998 for ^{14}C analyses to provide long-term accumulation rates and for textural analyses and stratigraphy to provide ground-truth data for seismic interpretations. Long cores are stored at the USGS in Menlo Park and their facilities are used for subsampling.

Laboratory analyses have concentrated on analyzing the 1-m long ROV push cores collected in collaboration with D. Orange, all of which are now completed. Additional cores from the mid-slope plateau have also been analyzed to provide adequate coverage of this important slope sedimentary environment and to constrain the sediment budget. ^{14}C and textural analyses of long cores continues.

During the past year, G. Mountain assisted me in planning the Deep Coring Meeting, which was held at the Skidaway Institute of Oceanography on 15-16 October, 1998. At this meeting, interested STRATAFORM scientists gathered to identify scientific questions to be addressed by deep cores (30-200 m sub-bottom) in both STRATAFORM sites and to suggest locations for these cores. I also presented results of STRATAFORM research at the International STRATACON meeting in Sicily this September.

RESULTS

Cores collected with the MBARI ROV provide a unique look at small-scale sedimentary processes because of the accuracy with which their locations are known and the images of the seabed provided prior to core collection. Rates of sediment accumulation calculated from cores collected inside a gully from the northern slope, inside a nearby pockmark in the same gully, and approximately 100-m outside of the gully are not significantly different, suggesting that sedimentary processes important in shaping these features on 100-y timescales do not differ. A core collected from the axis of the Eel Canyon in ~800 m water depth documents rapid accumulation of modern sediment in the canyon at rates of >1 cm/y, suggesting that the Eel Canyon is rapidly sequestering sediment and should therefore experience mass flows down canyon. This core, with its precise positioning, is significant because cores collected from surface ships have significant uncertainty in actual core location, and can represent an environment different than that sought (i.e., channel flank as opposed to channel floor).

The slope sediment budget has been revised downward 5% based on new data from the outer mid-slope plateau (600-800 m water depth). Sediments in this area exhibit decreased accumulation rates and

coarser grain-size, indicating that fine-grained fluvial material is not transiting the plateau to accumulate on the lower slope in volumetrically significant amounts. The budget now reveals that the upper slope and mid-slope plateau contain 15% of the river's annual discharge; a combined budget for the shelf, upper slope and mid-slope plateau documents that 65% of the annual sediment load is not accounted for in these areas.

Twenty ^{14}C dates have been obtained, which generally provide average long-term rates (1000-y timescale) in the range of 50-150 cm/ 10^3y . These rates are lower than those measured on 100-y timescales, as is typically observed when these two timescales are compared, because the long-term rates incorporate more small erosional or hiatal events within their time frame of reference.

In total, a suite of 139 cores has been collected to examine the processes of sediment accumulation, biological sediment mixing, and sediment delivery to the Eel River continental slope. Spatial surveys of accumulation rate (0.2-7.5 g/cm²y), surficial sediment grain size (4-8.5 ϕ), flood-related ^7Be distributions, and ^{234}Th inventories demonstrate that sediment is accumulating throughout the Eel River margin, reflecting a rapid and widespread redistribution of the Eel River's discharge.

IMPACT/APPLICATIONS

Results of this project demonstrate that processes typically associated with transitional stages of sea-level (i.e., direct supply of sediment to the slope and delivery of fluvial material to canyons) are actively occurring on the Eel River margin. As the open slope plays less of a role in the marginal sediment budget, canyons become more likely to be a major sink and/or conduit for fluvially derived material. The distribution of accumulation rates across the slope suggests that the slope is building up along the shelf break, where sediment is then remobilized and transported to the lower slope, by-passing the mid-slope, and in the heads of canyons, where periodic downcanyon flows may deliver sediment to the deep sea.

TRANSITIONS

Accumulation rate data on 100- and 1000-y timescales and textural data are being used by geotechnical research groups to better interpret their own observations and by geophysical groups to ground-truth their data. Shelf researchers are using my slope data to complement their data to gain a margin-wide perspective on the redistribution of fluvial material.

RELATED PROJECTS

H. Lee (USGS) and I have been working closely for the past four years, and plan to continue in our collaboration on the relationship between sedimentary processes and geotechnical properties. C. Sommerfield (USGS/WHOI) and I are cooperating closely to quantify long-term sediment accumulation rates and to develop the sediment budget for the shelf and slope. C. Nittrouer (UW) and I are collaboratively investigating canyon-head sedimentary processes. Information concerning the rates and modes of sediment supply and redistribution within the slope region, as will be provided by accumulation rate and sediment textural observations, are critical for ground-truthing M. Field and J. Gardner's (USGS) geophysical surveys and as input to Pratson's (Duke) modeling efforts and D. Orange's (UCSC) studies of the influence of tectonics on sedimentation patterns.

PUBLICATIONS

- 1998 Sedimentary Processes on an Accretionary Continental Margin (C. Alexander, T. Elfers, and A. Simoneau). Paper presented at the 1998 STRATACON Meeting, 14-20 September, Sicily, Italy.
- 1998 Spatial Variability in Sedimentary Processes on the Eel River Continental Slope (C. Alexander and A. Simoneau). *Marine Geology* (in press).
- 1998 ^7Be as a Tracer of Flood Sedimentation on the Northern California Continental Margin (C.K. Sommerfield, C.A. Nittrouer and C.R. Alexander). *Continental Shelf Research* (in press).